(12) UK Patent Application (19) GB (11) 2 223 194 (13) A

(43) Date of A publication 04.04.1990

(21) Application No 8920846.6

(22) Date of filing 14.09.1989

(30) Priority data
(31) 67884 (32) 03.10.1988 (33) IT

(51) INT CL[4]
B23B 29/034, B23Q 1/12

(52) UK CL (Edition J)
B3C C1A12 C1A16A C1A20 C1A3 C1B7F
B3B BMB1

(56) Documents cited
None

(58) Field of search
UK CL (Edition J) B3B BMB1, B3C, B3K, B3T
INT CL[4] B23B, B23C, B23Q

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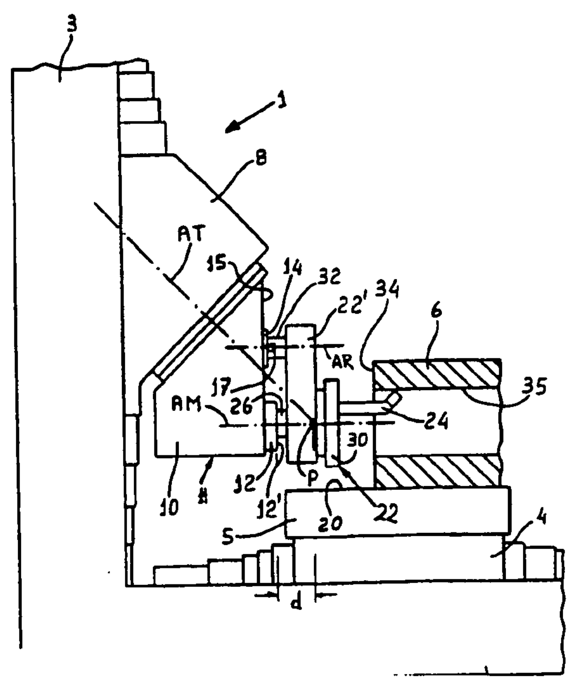
(54) Swivelling tool head

(57) The head (11) is provided with a tool carrying spindle (12) and can be rocked with respect to a frame (8) on an axis inclined 45°, to orientate the spindle in a vertical position or in an horizontal position. To effect facing works, boring works into holes of large diameter and conical boring works, a tool holder (22), is driven by the spindle (12). The holder (22) carries a device (22') for radially adjusting the tool (24), controlled by an auxiliary driving unit (14) located on the frame (8) parallel to the spindle and adapted to be clutched to the adjusting device when the tool holder is clutched to the spindle, the clutching not being affected by head swivelling. The spindle (12) is driven via gears from a hollow shaft in the head, a further shaft inside the first shaft providing, via worm gearing, the input to the auxiliary driving unit (14). Both shafts have joints allowing for axial movement of the head during uncoupling from the frame when being swivelled.



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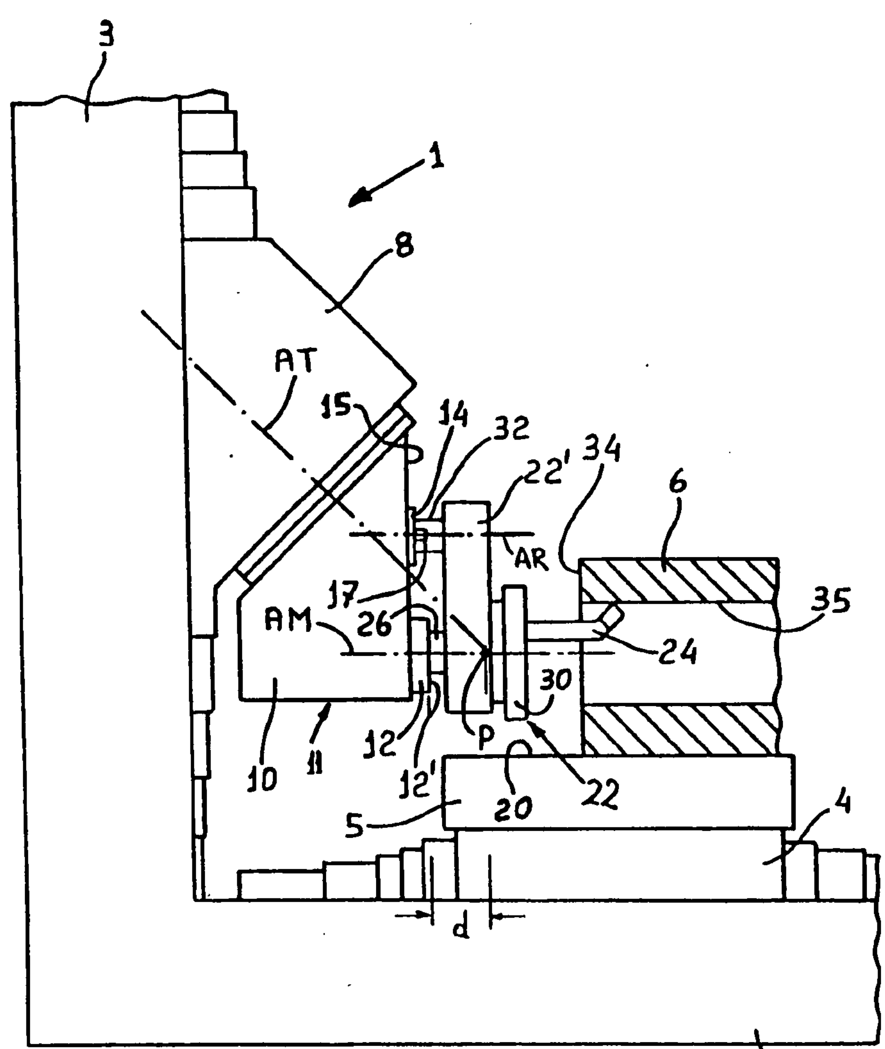

FIG.1

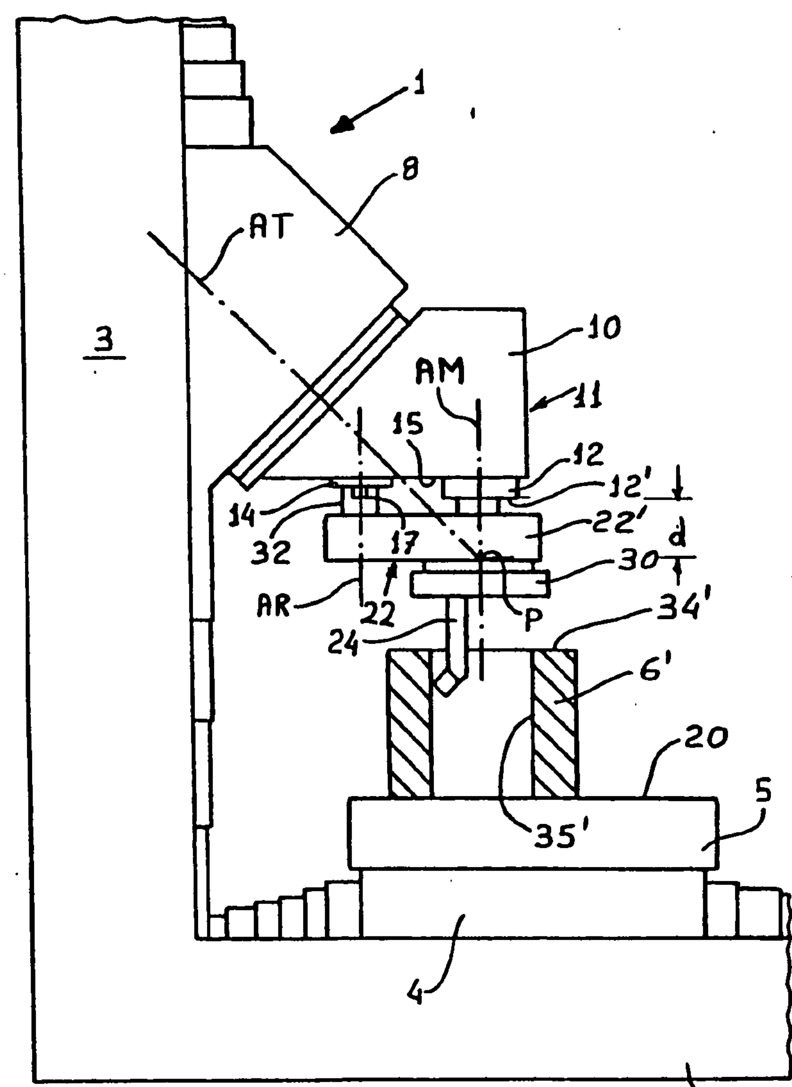

FIG.2

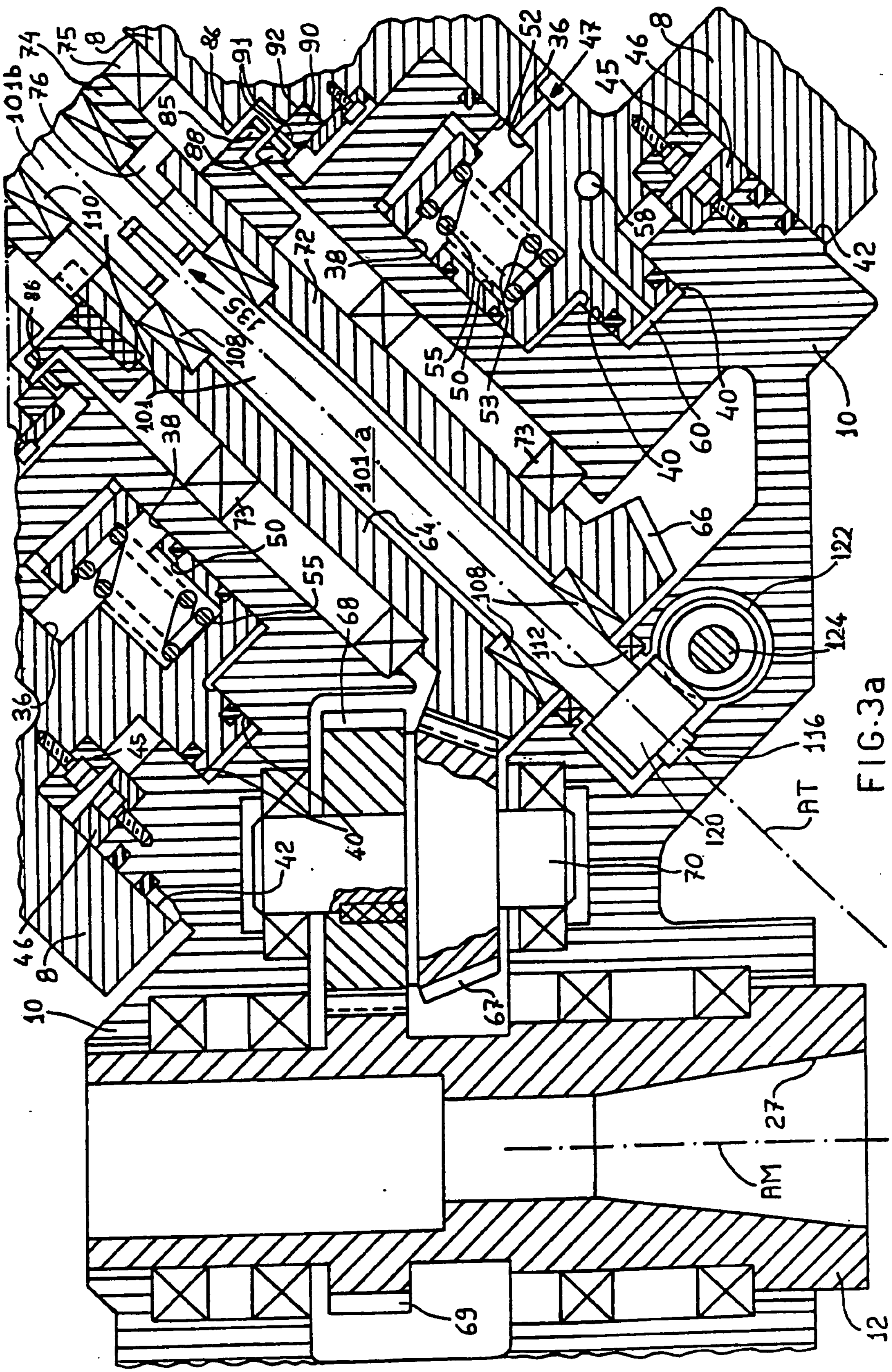
101b
76
74
75
8
86
91
92
90
52
36
47
46
45
85
88
110
72
38
135
108
101
101a
55
50
53
58
42
40
60
10
73
64
66
68
112
122
124
116
120
70
AT
67
27
AM
69
12

FIG.3a

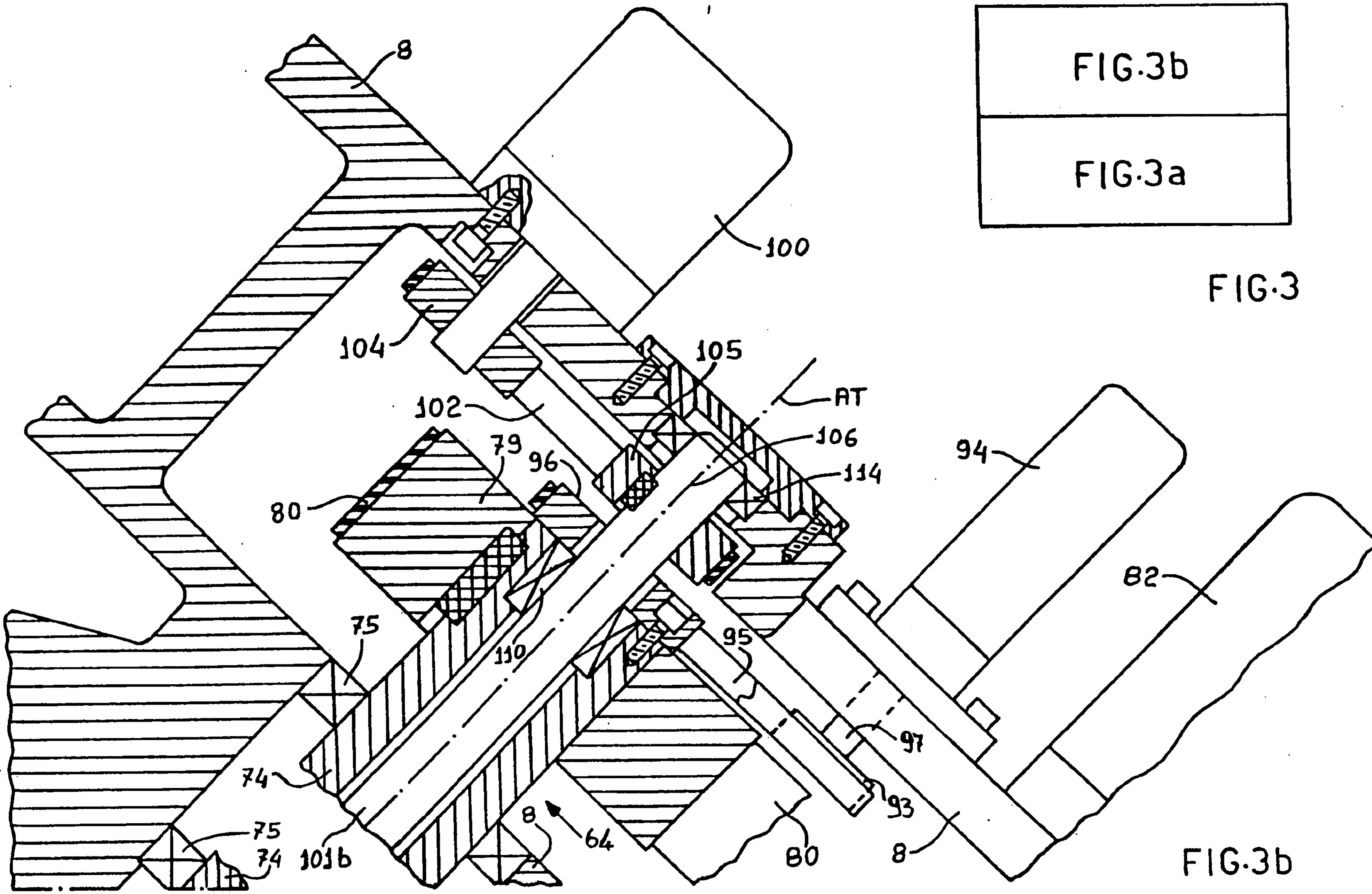
FIG.3b
FIG.3a
8
100
104
105
AT
102
106
79
96
114
94
80
82
75
110
95
97
74
93
75
8
64
74
101b
80
8

FIG.3

FIG.3b

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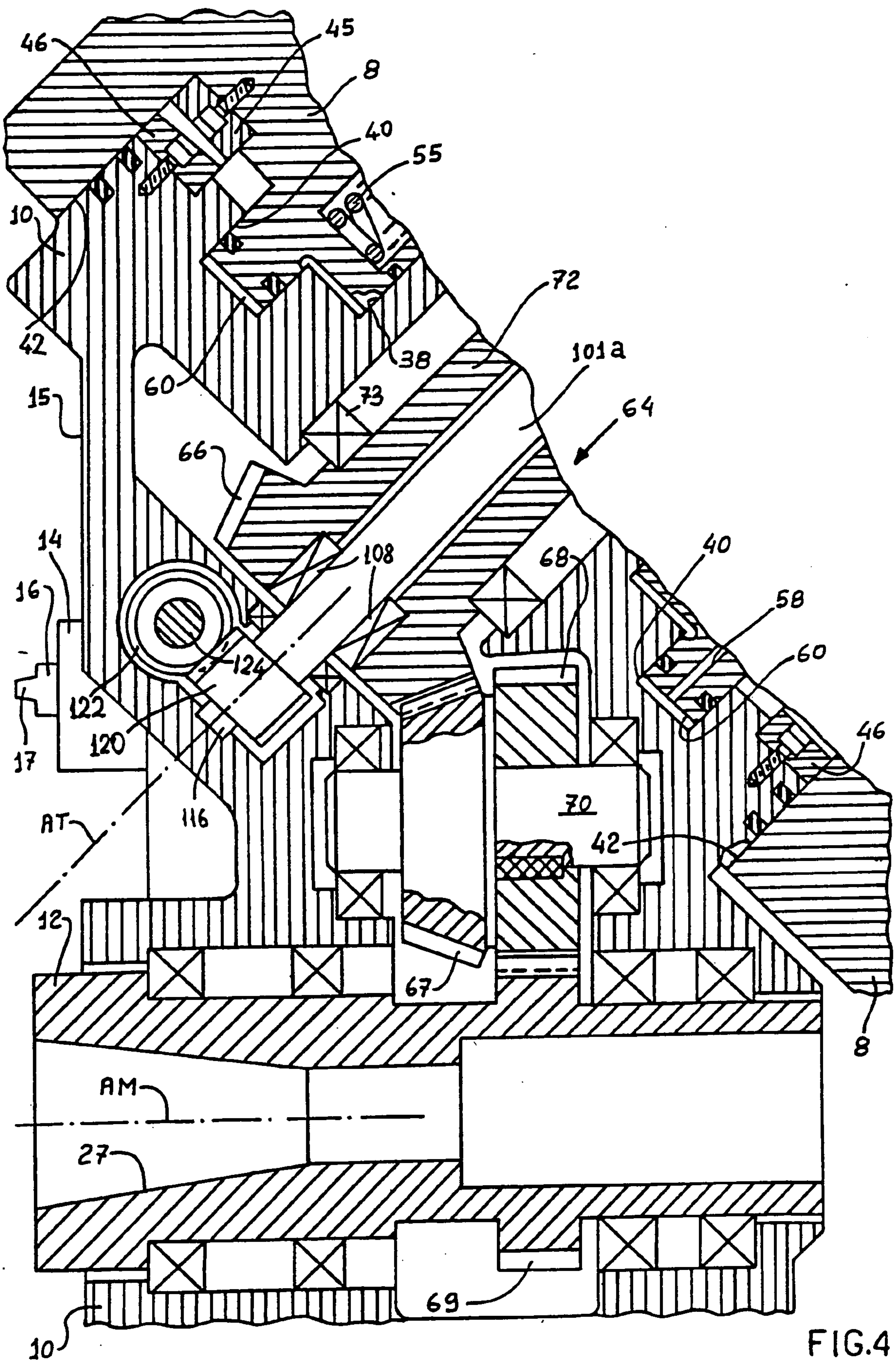

FIG.4

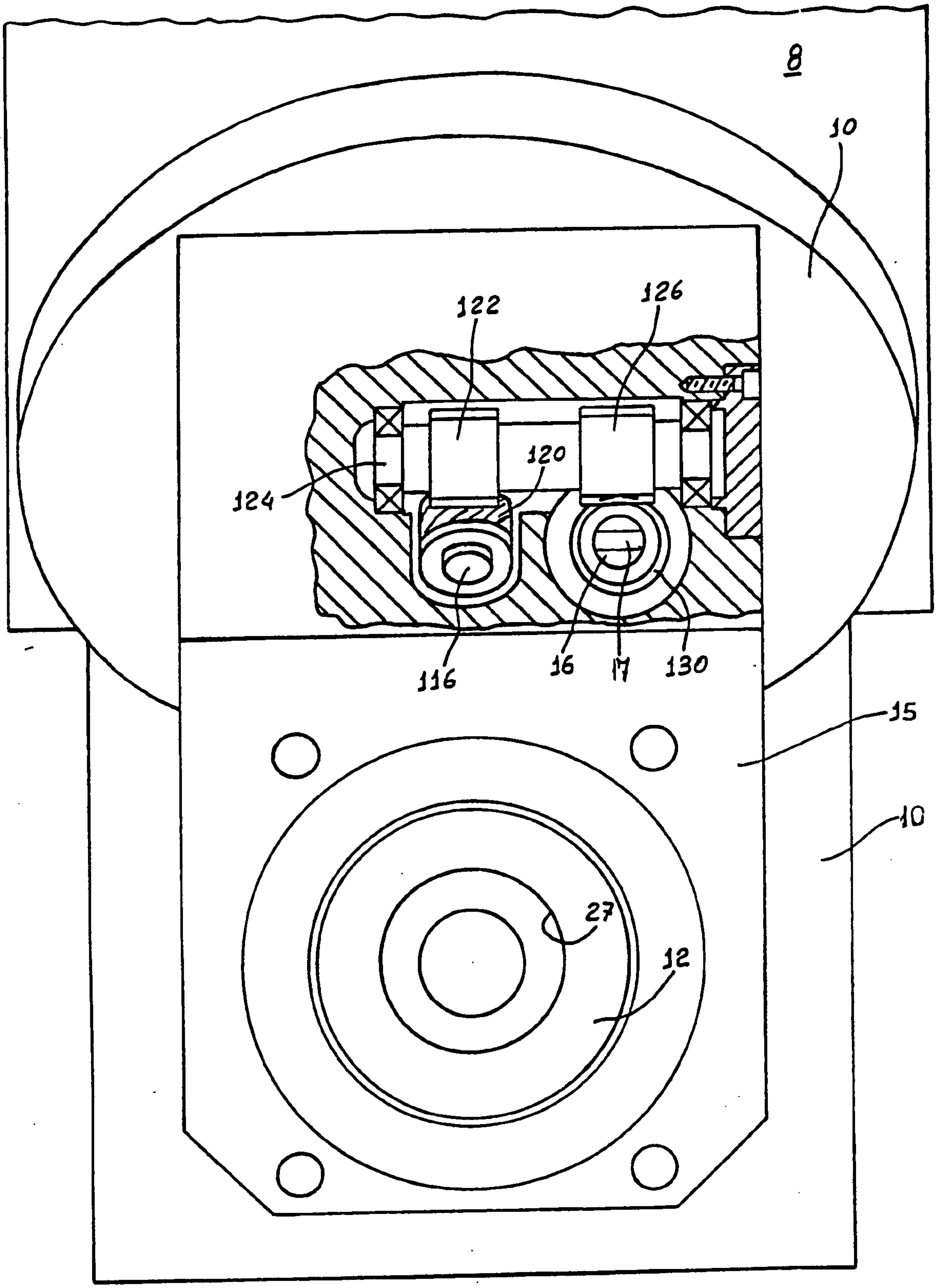

FIG.5

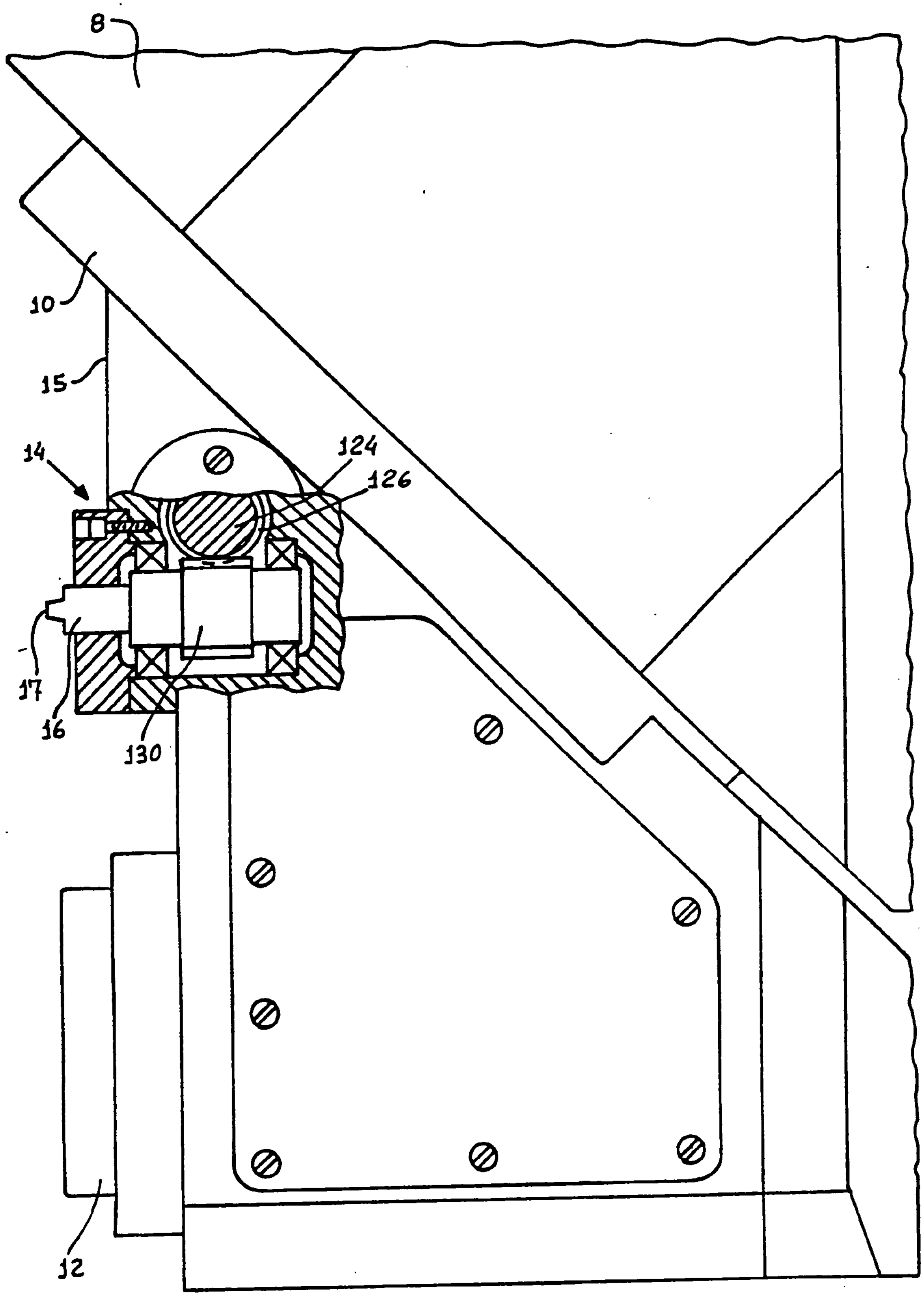

FIG.6

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WORKING HEAD FOR A NUMERICAL CONTROL MACHINE TOOL

This invention relates to a working head for a numerical control machine tool according to the preamble of the claim 1.

There are known several working heads rotatably mounted on an inclined axis either for selecting one of a group of tools or for selectively locating the spindle in the horizontal and in the vertical position.

There are also known some tool holders including a device for adjusting the radial position of the tool on the spindle to carry out boring and facing works. A tool holder of this type, described in the United States Patent No. 4,489,629, includes a conical member adapted to be inserted into the spindle, a rectilinear guide perpendicular to the rotating axis of the spindle being provided on the tool holder, for guiding a slide carrying the tool, to adjust the radial position of the tool on the tool holder. The slide is moved by a clutch member adapted to be engaged with a driving member carried by the machine frame. Therefore this tool holder is unadapted for altering the radial position of the tool both when the spindle works in the horizontal position and when it works in the vertical position.

The technical problem solved by the invention resides in providing a working head adapted to locate the spindle horizontally and vertically, which can be fitted with a tool holder including a device for adjusting the radial position of the tool.

This technical problem is solved by the working head according to the invention, which is defined by the characterising part of claim 1.

The characteristics of the invention will be more apparent from the following description of a preferred embodiment thereof, made by way of example, in conjunction with the accompanying drawings, wherein:

Fig. 1 is a diagrammatic view of a machine tool including a working head according to the invention, wherein the head is positioned with the spindle directed horizontally;

Fig. 2 is the machine tool of Fig. 1, wherein the working head is positioned with the spindle directed vertically;

Figs. 3a and 3b are the vertical section of the working head in the position of Fig. 1, in an enlarged scale;

Fig. 4 is a partial section of the working head in the position of Fig. 2, in an enlarged scale;

Fig. 5 is a partially sectioned front view of the working head of Fig. 4;

Fig. 6 is a partially sectioned lateral view of Fig. 5.

With reference to Fig. 1, the numeral 1 generically indicates a numerical control machine tool having a main frame 2 secured to a vertical upright 3. The frame 2 slidably mounts a slide 4 carrying a table 5, on which a workpiece 6 is secured for being machined. A support or frame 8 for a working head 11 is vertically slidable on the upright 3.

The working head 11 includes a structure 10, which is rockable with respect to the frame 8 around an axis AT

inclined 45° with respect to a horizontal working plane 20, represented for instance by the contacting surface of the workpiece 6 on the table 5. The head 11 is provided with a spindle 12 rotatable on the structure 10 around an axis AM and protruding from a front surface 15 of the structure 10.

The head 11 is also provided with an auxiliary driving unit 14 including a driving member or shaft 16 (Figs. 5 and 6). The shaft 16 is rotatable on the structure 10 around an axis AR (Fig.2) parallel to the spindle 12 and is also protruding from the surface 15.

The spindle 12 is adapted to clutch a tool holder generically indicated by 22, which is adapted to hold a tool 24 to be rotated around tha axis AM. The tool holder 22 includes a device 22' for radially moving the tool 24 on the tool holder 22, i.e. for radially adjusting the tool position. To this end the tool holder 22 is provided with a driven rod 32 having a radial end notch adapted to be clutched with a radial rib 17 (Figs. 4 and 6) of the shaft 16.

The tool holder 22 includes also a frusto conical rod 26 (Fig. 1) by means of which it may be inserted and connected, in a known manner, into a corresponding hollow 27 (Fig. 3) of the spindle 12. The rod 26 is secured to a connecting elment 30 (Figs. 1 and 2) of the tool 24. The tool holder 22 may be for example of the type described in the cited Patent No. 4,489,629, and therefore it needs not to be detailedly described.

In Fig. 1 the head 11 is located in a first position, as to orientate the spindle 12 with its axis AM parallel to the workpiece table 5, i.e. horizontal. The tool 24 of the tool holder 22, inserted into the spindle 12 in such a position is adapted to effect facing works on surfaces 34 of the workpiece 6 perpendicular to the plane 20 and boring works on holes 35 having an horizontal axis.

Fig. 2 shows the head 11 located in a second position, which is rocked 180° on the axis AT with respect to the position of Fig. 1, as to orientate the spindle 12 with its axis AM in the vertical direction. The tool holder 22 is therefore bodily rocked with the head 11 and remains connected both to the spindle 12 and to the auxiliary driving unit 14, the axis AR of which is also orientated vertically. In this second position, the tool holder 22 is adaped to effect facing works on a surface 34' of the workpiece 6' parallel to the plane 20 and to effect boring works on a hole 35' having a vertical axis.

The structure 10 of the head 11 is adapted to rotate, as well as to slide, on four cylindrical surfaces 36, 38, 40, 42 (Fig. 3a) of the frame 8, which are coaxial with the axis AT. The structure 10 can be locked in the two working positions shown in the Figs. 3a and 4, by means of a pair of mutually engaged front toothed rings 45 and 46 secured respectively to the frame 8 and to the structure 10.

The head 11 can be locked in each of the two working positions by supplying oil under pressure through a duct 47

into an annular hydraulic chamber 50 defined by the above mentioned cylindrical surfaces 36 and 38, and by two plane surfaces 52 and 53 provided respectively on the structure 10 and on the frame 8. A group of compression springs 55 mounted into the chamber 50 is capable of holding the toothed rings 45 and 46 in engagement, thus mantaining the structure 10 of the head 11 locked on the frame 8, even if the pressure of the oil accidentally fails.

To release the structure 10 from the frame 8, the oil under pressure is supplied through a duct 58 into a second annular hydraulic chamber 60. The oil thus displaces the structure 10 axially (downwards in Fig. 3a), upon overcoming the urge of the springs 55, and has the effect of disengaging the toothed rings 45 and 46 from each other.

The spindle 12 can be continuously rotated by a hollow main motor shaft, generically indicated by the numeral 64, which is coaxial with the axis AT. The shaft 64 operates through intermediate means including a pair of bevel gears 66 and 67 and a pair of cylindrical gears 68 and 69. The gear 66 is secured to the shaft 64, whereas the gear 69 is secured to the spindle 12. In turn the gears 67 and 68 are both secured to a pivot 70 freely rotatable on the structure 10. The axis AM of the spindle 12, the axis AT of the shaft 64 and the axis of the pivot 70 are lying on a single plane, coincident with the section plane of the Fig. 3a.

The two intermediate gears 67 and 68, being located between the shaft 64 and the spindle 12, enable this latter, when

located in the vertical position of Fig. 2, to be positioned at a distance from the upright 3 in the horizontal direction, which is greater than the distance of the conventional working heads, wherein the spindle is driven by the motor shaft simply through a couple of bevel gears. This arrangement of the head 11 enables the spindle 12 located in the vertical position to effect some special workings on a workpiece 6' fixed to a workpiece table 5 rotatable also on a vertical shaft, since it is possible to position the spindle 12 and the table 5 as to make the two axes coincident.

Furthermore, during the rocking motion of the head 11 on the axis AT (Figs. 1 and 2), the axis AM of the spindle 12 defines a conical surface having the vertex in a point P where the two axes AT and AM intersect each other. The vertex P is located at a distance "d" from the front face 12' of the spindle 12. Therefore, when the head 11 rocks from the position of Fig. 1 to the position of Fig. 2, the face 12' is displaced upwards the distance "d" with respect to the initial position of the axis AM. If a working is to be effected with the spindle 12 directed vertically, the head 11 must be raised by a stroke, which is reduced by the distance "d", thus sparing the corresponding time required for the relevant displacement.

The shaft 64 (Fig. 3a) is formed of two hollow coaxial portions 72 and 74. The portion 72 is mounted on the structure 10 and is rotatable on revolving bearings 73, whereas the portion 74 is mounted on the frame 8 and is

rotatable on revolving bearings 75 (see also Fig. 3b). Since the portion 72 must be displaced axially with respect to the portion 74 when the head 11 is released, the two portions 72 and 74 are mutually connected by an axial joint 76 (Fig. 3a) of any known type, for example an Oldham joint.

The portion 74 is rotated by an electric motor 82, only partially shown in Fig. 3b, driving a belt 80, which engages a pulley 79 secured to the portion 74. In order to rock the head 11 from the one to the other working position, when the head 11 is released, the motor 82 and the shaft 64 can be also operated in conjunction with control means 85, 88, 90. More particularly, these control means comprise a gear 85 secured to the portion 72 (Fig. 3a) of the shaft 64. When the structure 10 is in the locked position, the toothed portion of the gear 85 rotates bodily with the shaft 64 idly in an annular space 86 of the frame 8.

The control means also comprise a gear or toothed ring 88 integral with the structure 10, which is adjacent to, but separate from the gear 85, and has the same diameter of this latter. The gear 88 always meshes with an inner toothing 91 of a ring 90 coaxial with the axis AT and freely rotatable on an annular seat 92 provided on the support 8. The ring 90 has an axial dimension substantially equal to the sum of the thicknesses of the gears 85 and 88, whereby both these gears can be simultaneously in mesh with the toothing 91 of the ring 90.

When the structure 10 is released, the portion 72 of the

shaft 64 is axially displaced bodily therewith. The gear 85 is then displaced bodily with the portion 72 and enters in mesh with the toothing 91 of the ring 90. Since this latter is now in mesh with both gears 85 and 88, the shaft 64 remains angularly connected to the structure 10. If now the motor 82 is rotated, this latter rotates the shaft 64 and the gear 85, which by means of the ring 90 rotates also the gear 88. Therefore, the structure 10 is caused to be rocked from the one to the other of its working positions.

It is thus clear that, when the structure 10 is released by supplying oil to the hydraulic chamber 60, the shaft 64 is angularly connected to the structure 10. It is then sufficient to rotate the motor 82 a predetermined number of revolutions to rock the head 11 from the working position of Fig. 3a to the working position of Fig. 4 and viceversa.

The number of revolutions to be effected by the motor 82 is controlled by a conventional encoder 94 (Fig. 3b), which includes a pulley 93 secured to its shaft 97. The pulley 93 by means of a another belt 95 is connected to a small pulley 96 secured to shaft 64. The electric signals generated by the encoder 94 are processed in a known manner by a numerical control apparatus controlling the machine tool, in order to stop the motor 82 when the head 11 exactly reaches the one or the other of its working positions.

In any working position of the head 11, the auxiliary driving unit 14 (Fig. 6) is operable by an associated electric motor 100 (Fig. 3b) located outside the head 11, i.

e. in the stationary frame of the machine tool. More particularly, the motor 100 is mounted on the frame 8 of the head 11 and is connected to the driving unit 14 by means of a control shaft 101 housed into the hollow shaft 64 and therefore coaxial with the axis AT. The shaft 101 is operated by the motor 100 through a belt 102 driven by a pulley 104 secured to the shaft of the motor 100, and driving a pulley 105 secured to an upper end 106 of the shaft 101.

The shaft 101 can rotate irrespectively from both the rotation of the shaft 64 and the orientation of the head 11. As a matter of fact, the shaft 101 is supported by a first pair of bearings 108, 110 (Fig. 3a) mounted inside the shaft 64, and by a second pair of bearings 112 and 114 (Fig. 3b) mounted respectively on the structure 10 and on the frame 8.

The upper end 106 of shaft 101 protrudes upwards from the shaft 64, whereas a lower end 116 of the shaft 101 (Fig. 3a) protrudes downwards therefrom and is secured to a first worm gear 120. This latter meshes with an intermediate gear 122 secured to a shaft 124, which is rotatable on the structure 10 around an axis orthogonal to both the axis AM of the spindle 12 and the axis AT of the shaft 101. Secured to the shaft 124 is another gear 126 meshing with a second worm gear 130 (Figs. 5 and 6) secured to shaft 16 of the driving unit 14 which, as it was already told, is constantly clutched with the driven rod 32 (Figs. 1 and 2) of the device 22'.

It is evident that, due to the location of the shaft 101 (Figs. 3 and 4) coaxial with the rocking axis AT of the head

11, the cinematic connection between the motor 100 and the device 22', for radially adjusting the position of the tool on the tool holder 22, is made sure irrespectively from the position of the head 11. In fact, during the rocking movement of the head 11 around the axis AT, the gear 122 (Fig. 5) rolls with a planetary movement around the gear 120 of the shaft 101, thus maintaining constantly the mechanical connection between the shaft 101 and the shaft 16.

The motor 100 is operated only for adjusting the radial position of the tool 24 (Figs. 1 and 2) on the tool holder 22. The motor 100 is controlled in a known manner by the numerical control apparatus of the machine tool, as to displace the tool 24 with very high precision. The radial position of the tool 24 can be adjusted with a continuous movement during the working operation, when conical surfaces are to be worked, or when plane surfaces perpendicular to the axis AM of the spindle 12 are to be worked with a facing operation.

In order to allow the axial displacement of the structure 10 when this is to be released from the frame 8, the shaft 101 (Fig. 3a) is divided in two parts 101a and 101b. These parts are connected by a joint 135 allowing their mutual axial movement. Therefore, the part 101a connected to the structure 10 by the bearing 112 can translate with respect to the part 101b, which is axially held on the frame 8 by the bearing 114 (Fig. 3b).

It is evident that improvements, modifications and addition

of parts can be made to the described working head of a numerical control machine tool without departing from the scope of the invention. For example, the working head can be used in a machining center having an automatic tool changing device. The head 11 can also be rocked by rotating the motor 82 always in the same direction, instead of rotating it selectively in either of the two directions.

CLAIMS

1. A working head for a numerical control machine tool, having at least a rotatable tool carrying spindle, said head including a structure mounted on a frame as to be rocked on an axis inclined 45° with respect to a working plane to position said spindle selectively in a direction parallel and in a direction perpendicular to said working plane, said spindle being operated through intermediate means by a motor shaft coaxial with said axis, characterised in that said tool (24) is carried by a tool holder (22) adapted to be removably mounted on said spindle (12), said tool holder including a device (22') for adjusting the radial position of the tool on said tool holder, said device being automatically clutched with a driving member (16) when said tool holder is mounted on said spindle, said driving member being rotatable on said head parallely to said spindle, whereby said strucure (10) can be rocked on said frame bodily with said tool holder mounted on said spindle and with said device clutched to said driving member.

2. A working head according to claim 1, characterised in that said motor shaft (64) is hollow and said driving member (16) is rotated through motion transmitting means (120, 122, 124, 126, 130) by a control shaft (101) coaxial with said motor shaft.

3. A working head according to claim 2, characterised in that said motion transmitting means comprise a first gear (120) secured to said control shaft (101), a second gear

(130) secured to said driving member (16), and a pair of toothed wheels (122, 126) engaging said gears and secured to a rotatable shaft (124) orthogonal to both said control shaft and said driving member.

4. A working head according to claim 3, characterised in that the toothed wheel (122) of said pair (122, 126) engaging said first gear (120) during the rocking motion of said structure (10) on said frame (8) is moved with a planetary motion relatively to said control shaft (101), whereby said driving member (16) is not affected by said rocking motion.

5. A working head accoding to claim 4, characterised in that said motor shaft (64) is continuously rotated by a main electric motor (82), said control shaft (101) being rotated by a numerically controlled electric motor (100).

6. A working head according to any preceding claim, characterised in that said structure (10) is axially movable along said inclined axis (AT) with respect to said frame (8) from a locked position to a released position, control means (85, 88, 90) being provided for causing said structure to rock 180° on said inclined axis when it is located in said released position.

7. A working head according to claim 6, characterised in that said motor shaft (64) comprises a first hollow portion (74) rotatably mounted on said frame (8), and a second hollow portion (72) rotatably mounted on said structure (10) coaxially with said first portion, axial joint means (76) being provided between said first portion and said second

portion for transmitting the rotation from said first to said second portion and for allowing the axial displacement of said structure.

8. A working head according to claim 7, characterised in that said control shaft (101) is formed of two parts (101a, 101b) rotatably mounted respectively on said frame (8) and on said structure (10), said parts being mutually connected by an axial joint (135) for transmitting the rotation from said first part to said second part and for allowing the axial displacement of said structure.

9. A working head according to any claim from 6 to 8, characterised in that said said control means (85, 88, 90) comprise a first connecting member (85) and a second connecting member (88) secured respectively to said motor shaft (64) and to said structure (10), and an intermediate element (90) for connecting said first and second connecting members when said structure is displaced to said released position, whereby said structure can be rocked by rotating said motor shaft.

10. A working head according to claim 9, characterised in that said intermediate element (90) is connected to said second connecting member (88) when said structure (10) is located in said locked position, and is connected to both said connecting members (85, 88) when said structure is located in said released position.

11. A working head according to claim 9 or 10, characterised in that each one of said connecting members

comprises a connecting gear (85, 88) and that said intermediate element comprises an internally toothed ring (90) coaxial with said inclined axis and freely rotatable on said frame (8), said thooted ring being selectively engageable by one or both said connecting gears.

12. A working head according to any previous claim, characterised in that said intermediate means include a first pair of gears (67, 68) bodily rotatable on said structure (10) and engaging a second pair of gears (66,69) secured respectively to said motor shaft (64) and said spindle (12), said inclined axis (AT), the axis (AM) of said spindle and the axis of said first pair of gears being complanar, whereby when said structure (10) is rocked to locate said spindle perpendicularly to said working plane (20), the end of said spindle results displaced a predetermined distance (d) from said plane.